september 1958

nlgi spokesman

journal of the national lubricating grease institute

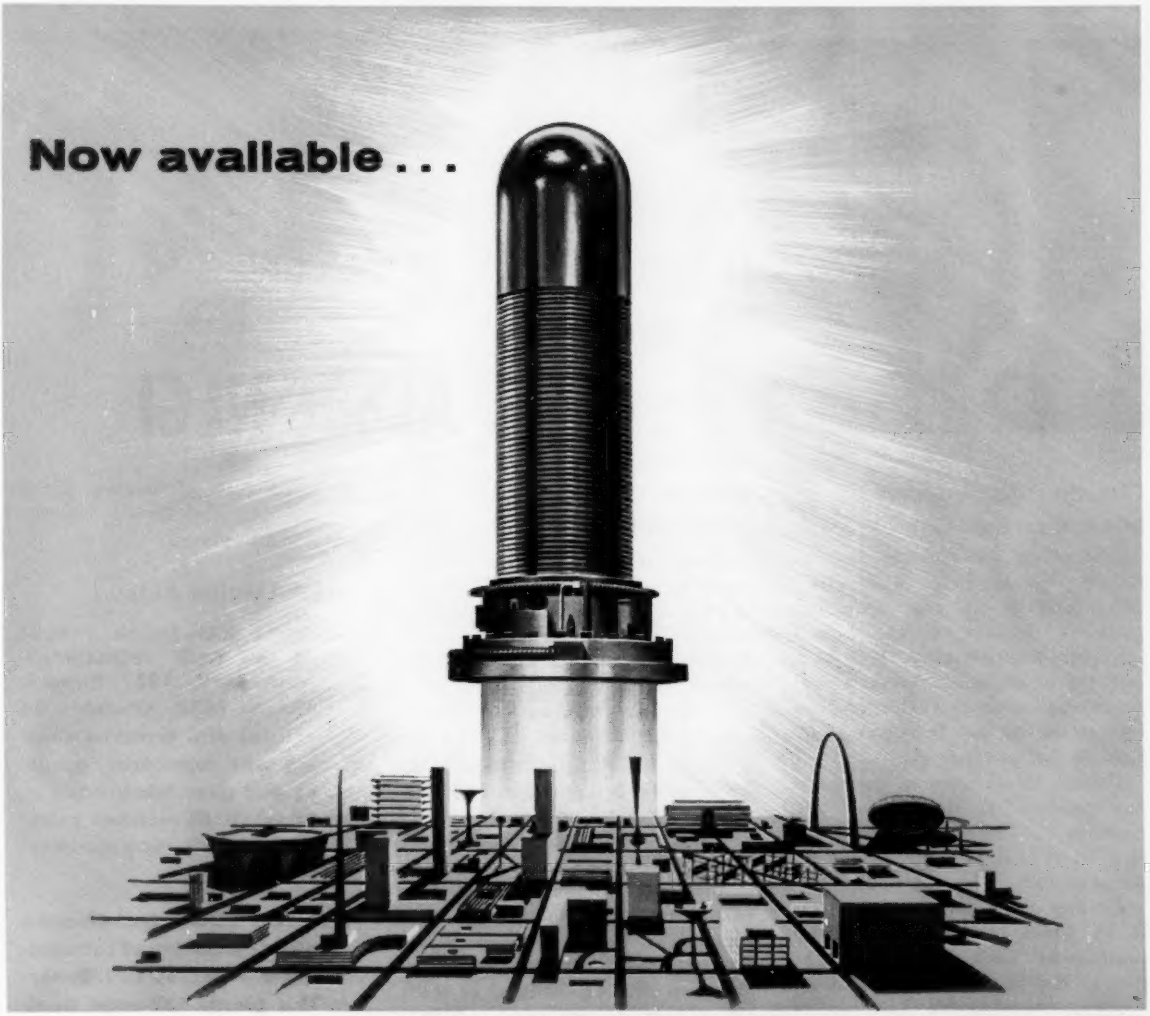
Previews—NLGI Annual Meeting

Grease Bleeding—A Factor in Ball Bearing Performance

By A. E. BAKER

Tensive Stresses on Lubricating Greases Reduce Bleeding

By DEAN W. CRIDDLE and JAY CORTES, Jr.



Van de Graaff electron accelerator recently installed at Shell's Emeryville Research Center is one of the most powerful sources of radiation available to industry.

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News About NLGI

Changes Announced in NLGI Representatives

Consumers Cooperative association has named Leonard F. Cowden, director of the petroleum products division, as the NLGI Company Representative. R. P. Lee, director of technical research, will continue to serve as Technical Representative to the Institute. CCA is an Active member firm.

Climax Molybdenum company has appointed K. B. Wood to the position of Technical Representative to NLGI for this Associate member firm.

Darling and Company has given R. H. Jones, technical service, the position of Technical Representative to the Institute. Darling is an Associate member.

Stratford Engineering, an Associate member, asked Ward A. Graham to serve as NLGI Technical Representative.

80 Prints Sold of "Grease—the Magic Film"

More than eighty prints of the NLGI movie "Grease–the Magic Film" have been sold around the world . . . an increase of more than 21 copies of the movie since the last report to readers in the Institute's journal, three months ago. Partly subsidized by the Institute, the picture is designed to serve a number of publics and preview copies are still available without charge from the national office, for firms interested in this promotion medium.

Enough Copies of the NLGI SPOKESMAN?

Does your organization receive enough copies of the NLGI SPOKESMAN to do the job you want? Many member firms find that the membership subscriptions allotted on the basis of dues are not enough . . . they then purchase subscriptions at the member discount.

For NLGI'ers, the regular $5.00 subscription is reduced to $2.50 for one year's subscription . . . the $6.00 overseas charge is reduced to $4.00. This member service allows inexpensive distribution of the journal to field men, customers and consumers, or to supplement copies within the firm. A magazine can begin with the current issue or with the current volume (April, 1958).

Those member firms that would like to re-evaluate their membership subscription lists may do so by writing the national office. A listing of all NLGI SPOKESMAN mailings for the firm will promptly be sent for review.

Third Set of Terms and Definitions

The third set of terms and definitions relating to the lubricating grease industry have been sent to the Technical Committee by the Technical sub-committee engaged in this work.

Earlier, the first set of terms was printed in the NLGI SPOKESMAN last year. A second set is now being prepared for publication in the journal, and after review, the third set will be offered.

NLGI Service Aids

VOLUME XXI—Bound volume of the NLGI SPOKESMAN from April, 1957 through March, 1958. Contains 34 articles and features dealing with lubricating greases and gear lubricants . . . $7.00 (NLGI member price) and $10.00 (non-member) plus postage.

BONER'S BOOK—Manufacture and Application of Lubricating Greases, by C. J. Boner. This giant, 982-page book with 23 chapters dealing with every phase of lubricating greases is a must for everyone who uses, manufactures or sells grease lubricants. A great deal of practical value. $18.50, prepaid.

NLGI MOVIE — "Grease, the Magic Film," a 16-mm sound movie in color running about 25 minutes, now released. First print $600, second print $400, third and subsequent orders $200 each (non members add $100 to each price bracket).

NEW EMOLEIN® 2910 LOWERS COST OF SYNTHETIC LUBRICANTS

Emolein 2910 Lubricant Ester, formerly designated Emery 3033-S, is the answer to lower-cost synthetic fluids and greases required by the jet age. In synthetic fluids, total cost can be reduced substantially by blending Emolein 2910 with an azelate diester without sacrificing performance. In greases, Emolein 2910 can be used alone or by blending with other fluids.

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Future Meetings

SEPTEMBER, 1958

8 NLGI Board of Directors meeting, New York City, location to be announced.

10-12 National Petroleum Association, 56th Annual Convention, Traymore Hotel, Atlantic City, N. J.

21-24 AIME, Conference on Petroleum, Cosmopolitan Hotel, Denver, Colo.

24-25 Oil Petroleum Marketers Association Fall Conference and Golf Tournament, Dayton Biltmore Hotel and Walnut Grove Country Club, Dayton, Ohio.

28-30 IOCA Eleventh Annual Meeting, Palmer House Hotel, Chicago, Ill.

OCTOBER, 1958

6-7 Packaging Institute, Petroleum Packaging Committee, Sheraton - Fontenelle Hotel, Omaha.

12-14 Oil Progress Week

13-15 ASLE-ASME Joint Lubrication Conference, Hotel Statler, Los Angeles, Calif.

20-22 SAE National Transportation Meeting, Lord Baltimore Hotel, Baltimore, Md.

22-24 SAE National Diesel Engine Meeting, Lord Baltimore Hotel, Baltimore, Md.

27-29 NLGI Annual Meeting, Edgewater Beach Hotel, Chicago, Ill.

NOVEMBER, 1958

5-6 SAE, national fuels and lubricants meeting, the Mayo Hotel, Tulsa.

6-8 National Oil Jobbers Council, Conrad Hilton Hotel, Chicago.

10-12 API annual meeting, Conrad Hilton Hotel, Chicago.

30-Dec. 5 ASME, annual meeting, Statler and Sheraton-McAlpine hotels, New York City.

JANUARY, 1959

25-27 ASLE gear symposium, Hotel Morrison, Chicago.

FEBRUARY, 1959

2-6 ASTM National Meeting, William Penn Hotel, Pittsburgh, Pa.

***MARCH, 1959**

3-5 SAE Passenger Car, Body, and Materials Meeting, Sheraton-Cadillac, Detroit, Mich.

APRIL, 1959

21-23 ASLE Annual Meeting and Exhibit, Hotel Statler, Buffalo, New York.

MAY, 1959

15-24 International Petroleum Exposition

31-June 6 Fifth World Petroleum Congress.

JUNE, 1959

14-19 SAE Summer Meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

*Tentative

NLGI PRESIDENT'S PAGE

By R. CUBICCIOTTI, *President*

A Better Product—Our Constant Concern

With new automobile models ready to roll off the assembly lines, the time may be propitious for another re-evaluation by the members of the lubricating grease industry of the state of their product.

Of course, no one expects the producer of lubricating grease to emulate his counterpart in the automobile industry by coming out with a new type of grease every year. Conversely, the fact that our industry does not unveil a "new model" grease annually is no indication that we are not constantly seeking to improve our product in composition and performance.

After all, a new model car does not outdate the type of grease that was used to lubricate last year's automobile. Nor is progress in our industry dictated solely by the advances in allied fields; an important factor is the realization that our constant concern should be a better product per se.

But this particular event which is of such great import to the automobile industry, has a special significance for our industry that should not be overlooked. It suggests very strongly that we must be alert to any changes that may in any way affect our product, whether they be innovations in the method of lubrication feed or new types of bearings.

Aside from the possibility that such changes may necessitate the development of new grease products, the appearance of a new model underscores the value of a good lubricating grease to the life expectancy of an automobile. For at this precise time consumer interest in things automotive is greatly heightened. And if forecasts from the front offices of leading auto makers are based on more than personal optimism, public response to the new cars will be much greater this year than it has been for the past two years.

This heightened interest presents us with a fruitful opportunity to get across to the public one of our primary objectives: To make the 1000-mile lubrication a standard, automatic procedure. At no other time is the average car owner so concerned with protecting his investment than when he makes his purchase.

We may at times think we have reached the limit of our capabilities in so far as our product is concerned, or the limit of our opportunities to increase the acceptance by the public of the need for regular automobile lubrication. The appearance of the 1959 models, however, tells us, in its subtle way, that even a superior product can be improved each year—and that the American public is willing and ready to accept such product improvements. ■

nlgi spokesman

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IN THIS ISSUE

THE COVER

EXACT weight of each test specimen is recorded by researcher Bill Ashe for comparison with control specimens, to determine exact bleeding rate. Test procedures account for evaporation losses at the materials and processes laboratory of General Electric's aircraft accessory turbine department at Lynn, Massachusetts. The work shown here is taken from the paper by A. E. Baker entitled *Grease Bleeding—a factor in Ball Bearing Performance*, which begins on page 271, and is another in the series of papers on grease bleeding, in a symposium at the 1957 Annual Meeting.

previews of the 26th .....

NLGI ANNUAL MEETING

Edgewater Beach Hotel

Chicago

October 27 - 29, 1958

"LUBRICATING GREASE in INDUSTRY" is the theme of NLGI's 26th Annual Meeting, concluding the Institute's 25th Anniversary year with an exceptional program which fills two and a half days. Technical and marketing personnel will have an opportunity to keep posted on the latest and most effective techniques and methods in the industry, at the Edgewater Beach Hotel in Chicago, Monday, Tuesday and Wednesday, October 27, 28 and 29. The National Lubricating Grease Institute's session will bring together more than 500 experts representing an international industry group. Members and friends of NLGI are invited to attend this outstanding meeting—see you in Chicago!

"LUBRICATING

Rheology Symposium

NLGI's Fundamental Research group, a sub-committee of the Technical Committee, will conduct a symposium on rheology of lubricating greases which will be the most comprehensive symposium on this subject ever presented by any organization, to date. The stress will be on "pure" research. Because of the interest evidenced, this will be a special session running concurrently with the general meeting.

Joint AGMA-NLGI Session

INDUSTRIAL gear lubrication will be the subject in a joint meeting between the Institute and the American Gear Manufacturers Association. Six papers will cover design of gears and developments in lubricants, problems of the gear, the dispensing equipment and the lubrication manufacturers, as well as the thinking of

GREASE IN INDUSTRY”

the all-important consumer of both products.

Marketing

FUTURE grease requirements will be dealt with in three separate papers, including the automotive grease market, requirements for the steel and underground coal mining industries, and an explanation of current and future military requirements. The viewpoints of the service station and automobile dealers are two more talks of interest to marketers .There will be a paper on the bulk shipment of grease, and another on the facts and factors in grease manufacturing costs, along with the scientific detection of grease problems.

Milling of Grease

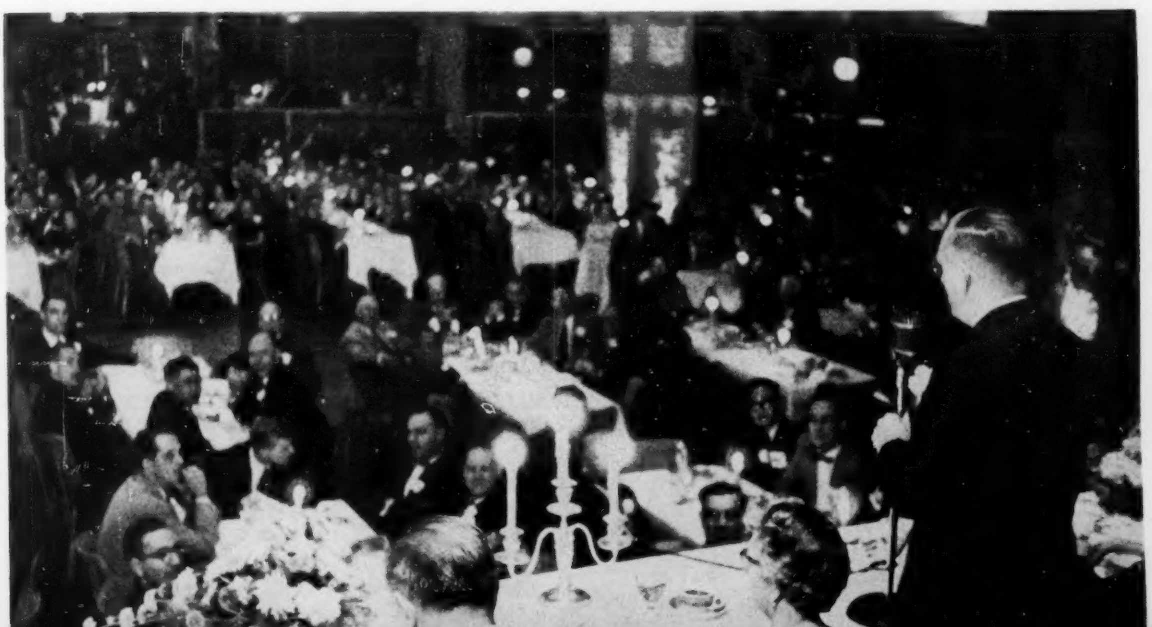
WHY milling is necessary, and the practical application of milling as it applies to the manufacture of various types of soap bases used in petroleum lubricating greases, are the subjects in this area.

NLGI Technical Committee Meeting

PROGRESS of the eight Technical sub-committees will be reported, future industry cooperation and planning mapped out. Technical papers of interest are scheduled, in addition to those to be given at the symposium on rheology mentioned above.

General

OTHER papers (see next page) are designed to offer a complete program, make this Annual Meeting the finest in the history of the National Lubricating Grease Institute's first quarter-century.



Schedule of NLGI Annual Meeting Papers

FACTS AND FIGURES IN GREASE MANUFACTURING COSTS, *Marvin S. Mingledorff*, International Lubricants Company, New Orleans.

A PREFORMED ORGANIC THICKENING, by *E. J. Kline* of Amoco Chemicals Corporation, co-authors *W. L. Haynes, Jr.*, and *T. P. Traise* of Standard Oil (Indiana), Chicago.

MARKET POTENTIAL FOR AUTOMOTIVE GREASE, *W. M. Drout, Jr.*, Esso Standard Oil, New York.

FUTURE GREASE REQUIREMENTS—STEEL AND UNDERGROUND COAL MINING INDUSTRIES, *J. C. Van Gundy*, The Texas Company, Pittsburgh.

CURRENT AND FUTURE MILITARY REQUIREMENTS, *R. J. Howrath*, Military Petroleum Supply Agency, Washington.

SCIENTIFIC DETECTION IN GREASE LUBRICATING PROBLEMS, *R. J. Ronan* and *M. C. McLaren*, The Texas Company, Beacon, N. Y.

MILLING OF GREASE—THE MECHANICS OF DISPERSION, *K. H. Birkett*, Battenfeld Grease and Oil Corporation, Inc., Kansas City.

PRACTICAL APPLICATION OF MILLING, *J. J. Dickason*, Jesco Lubricants Company, Kansas City.

LUBRICATE FOR SAFETY EVERY 1000 MILES—FROM THE SERVICE STATION DEALER'S VIEWPOINT, *Gordon Leonard*, Pure Oil dealer, Highland Park, Ill.

LUBRICATE FOR SAFETY—FROM THE CAR DEALER'S VIEWPOINT, *Myron Borski*, O'Malley Oldsmobile, Chicago.

GAS CHROMATOGRAPHY FOR ANALYSIS OF FATTY ACIDS, *Dr. K. P. Dimick*, Wilkens Instrument and Research, Inc., Walnut Creek, Calif.; co-authors *G. W. Collins*, Humko Company, Memphis, and *Dr. W. A. Link*, Archer-Daniels-Midland Company, Memphis.

BULK SHIPMENTS—TWO TONS OF GREASE, *John Waite, Jr.*, Inland Steel Company, East Chicago.

DEVELOPMENT OF EXTREME PRESSURE GREASES, *Dr. R. K. Smith*, E. F. Houghton and Company, Philadelphia.

INDUSTRIAL GEAR LUBRICATION, a joint panel discussion with the American Gear Manufacturers Association, featuring:

- INDUSTRIAL GEAR DESIGN (AGMA)
- GEAR MANUFACTURER'S VIEWPOINT (AGMA)
- LUBRICATION MANUFACTURER'S VIEWPOINT (NLGI)
- CONSUMER'S VIEWPOINT (AGMA-NLGI)
- RECENT DEVELOPMENTS IN INDUSTRIAL GEAR LUBRICANTS (NLGI)

Members of the panel at this writing include G. H. Davis of Shell Oil Company, New York, and Ehrman S. Reynolds, Socony-Mobil Oil Company, New York. Other participants will be announced at a later date.

A special session to run concurrently with the general meeting will be held by the Fundamental Research sub-committee of the NLGI Technical Committee. This group will offer a symposium on rheology and the stress will be upon "pure" research. Participants include:

AN EQUATION FITTING THE FLOW OF LUBRICATING GREASE IN VISCOMETERS AND PIPES, *A. W. Sisko*, *L. C. Brunstrum* and *R. H. Leet*, Standard Oil Company (Indiana), Whiting, Indiana.

YIELD POINTS OF LUBRICATING GREASES, *J. L. Dreher* and *D. W. Criddle*, California Research Corporation, Richmond, California.

PRESSURE AND TEMPERATURE EFFECTS ON THE FLOW PROPERTIES OF GREASE, *Dr. Henry Eyring*, University of Utah, Salt Lake City.

COMPARISON OF TEMPERATURE EFFECTS ON THE FLOW PROPERTIES OF GREASES IN CAPILLARY AND IN CONE AND PLATE VISCOMETERS, *Prof. W. A. Bauer*, Rensselaer Polytechnic Institute, Troy, New York.

Other Annual Meeting Highlights include the address by the keynote speaker, *Dr. Ray P. Dinsmore*, vice president of the Goodyear Tire and Rubber Company, Akron . . . the NLGI Annual Business Meeting . . . the traditional Social Hour and Banquet (informal) . . . and the NLGI Technical Committee meeting.

NLGI 26TH ANNUAL MEETING, EDGEWATER BEACH HOTEL, CHICAGO, OCTOBER 27, 28, 29, 1958. REGISTRATION FIVE DOLLARS (MEMBERS) AND TEN DOLLARS (NON-MEMBERS), BANQUET TEN DOLLARS AND SOCIAL HOUR THREE DOLLARS. FOR FURTHER INFORMATION PLEASE CONTACT: NATIONAL LUBRICATING GREASE INSTITUTE, 4638 J. C. NICHOLS PARKWAY, KANSAS CITY 12, MISSOURI. (PHONE) VALENTINE 1-6771. T. W. H. MILLER, EXECUTIVE SECRETARY.

Grease Bleeding—A Factor in Ball Bearing Performance

By A. E. Baker
General Electric Co.

Presented at the NLGI 25th annual meeting in Chicago, October, 1957

I. Introduction

IF WE CONSIDER grease as an oil storehouse for bearings, then the manner in which the grease releases the oil to its consumer, the bearing, is of singular importance. Depending upon factors such as load, speed, temperature, geometry, etc., design bearing life normally is measured in thousands of hours. Therefore, it follows, assuming grease bleeding is an important factor in bearing life, that order to develop more significant relationships.

An ideal grease, from a bleeding point of view, can be characterized as a lubricant which delivers the optimum amount of oil at a controlled rate to satisfactorily lubricate a ball bearing at its operating conditions. Thus the objective use of bleeding data determined over extended periods of time at various temperatures should be useful in explaining ball bearing performance.

Because there are many factors of equal or possibly greater consequence to bearing life, we recognize that the development of absolute relationships between bearing life and grease bleeding characteristics requires a rather subtle analysis. In this discussion, we will consider the significance of relative values and trends as determining factors.

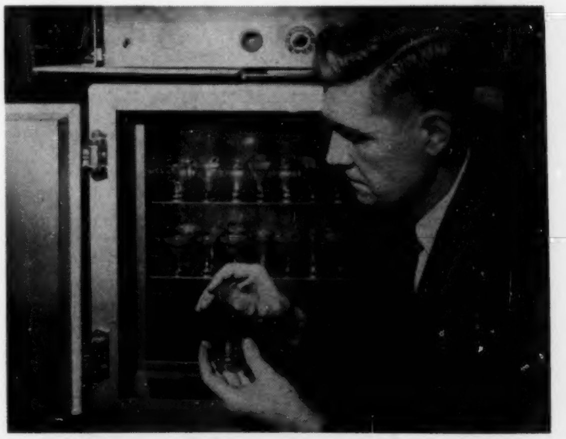
The bleeding data presented in this paper includes some of the information obtained over a period of approximately ten years during which time nearly every available type of ball and roller bearing grease was examined. Among the soap bases included were sodium, calicium, lithium, aluminum, and strontium as well as the non-soap thickeners silica and bentone. Likewise, there was an equal variety of fluids studied such as silicones, silicon-diester, polyglycol and naphthenic and paraffinic oils.

II. Bleeding Measurement

The technique used to obtain the bleeding data is similar to the method described in the MIL-G-3278 specification. Although considered not an ideal test method, the results have been useful in evaluating grease bleeding tendencies. The actual procedure evolved is a modification of this specification method, wherein the scope has been expanded to include much longer periods of time and the use of a two beaker technique to permit alternate collection of the oil bleeding from the greases during preselected time intervals. This scheme allows the determination of oil losses and subsequent correction for oil evaporation. Actual cumulative losses therefore can be measured.

Briefly the method involves placing approximately ten grams of grease in a wire mesh cone supported on the rim of a 250 ml. beaker which catches the oil bleeding from the grease. The vessel plus the oil is weighed after selected periods and the bleeding calculated as weight percent oil. For the next period, the cone and grease drain into the alternative beaker. Evaporation losses in the first beaker during the succeeding interval serve as a basis for establishing an evaporation correction for total oil bled in both beakers. The corrections are applied at each weighing. More frequent weighings are at the beginning of a test in order to record the rapid changes that occur in the bleeding rate. However, in approximately 500 hours, all greases reach a leveling off point at which time they continue to bleed at more uniform rates.

We recognize that bleeding per se is dependent largely on the soap structure. There are two mechanisms responsible for the loss of fluid from a grease; one, the hydrostatic pressure which forces the oil out of the interstitial spaces and the other, a squeezing out by a shrinking soap structure. In such a system, a rough indication of the relative bleeding tendencies can be determined by observing the particle size of the fibrous crystallites of the soap in various greases[5]. Soaps having large particles and therefore greater interfiber spacings will exhibit higher bleeding rates, but actual bleeding values, however, can only be obtained from a quantitative procedure such as that briefly outlined.



GREASE specimens are inspected by the author after 500 hours high temperature test. Oil that has bled through fine-screen cone is contained in beaker for measurement.

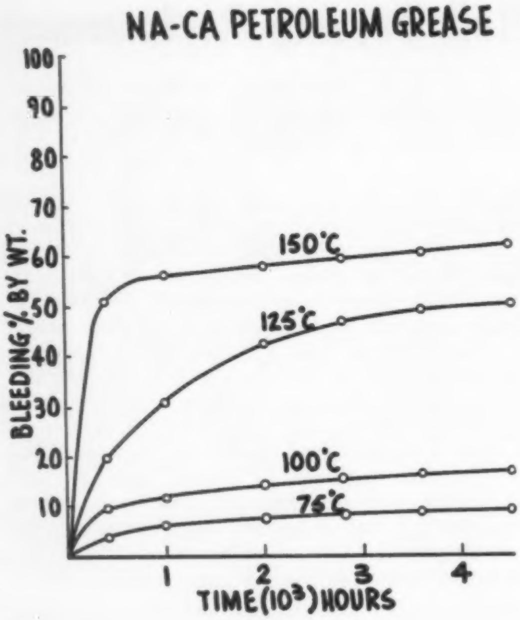


FIGURE 1

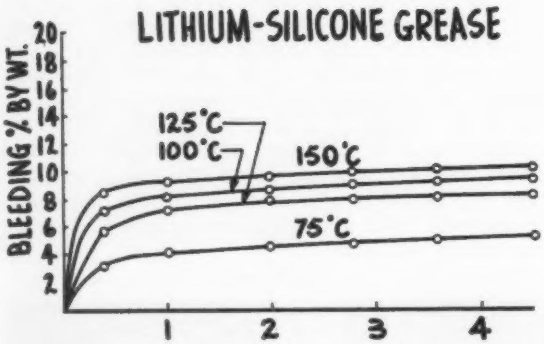


FIGURE 2

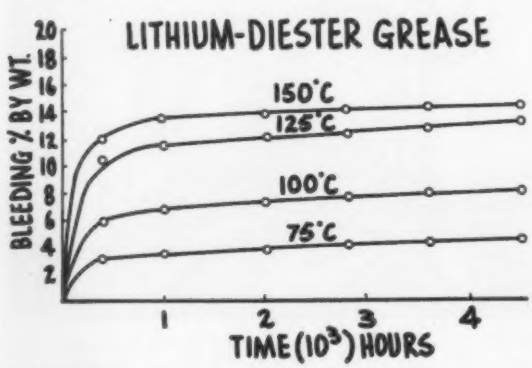


FIGURE 3

In order to investigate for possible relationships at several operating temperatures, and ultimately provide a basis for a more rigorous analysis of the results, the bleeding tests were conducted at 44°C, 75°C, 100°C, 125°C and 150°C. In general these temperature levels cover the operating ambients of the majority of conventional grease lubricated ball bearing applications.

III. Bleeding Characteristics

Following the procedure outlined, the results will yield data to express bleeding tendencies for each grease as shown in Figures 1, 2, and 3 where bleeding (oil lost in percent by weight) is plotted as a function of time and temperature. Comparing the family of curves for each grease, it can be seen that both the silicone and lithium greases are less temperature sensitive (bleed less oil) over the tested range than the soda calcium petroleum grease[8], thus indicating they would be superior for hotter bearings. Furthermore, it can be deduced from the curve on the latter grease that a probable maximum operating limit for long life occurs at approximately 100°C since in the next 25 degree increment, the bleeding losses more than double. Actual bearing tests confirm this conclusion for the mean life at 125°C is usually less than half of the 100°C life for this type of grease.

The three sets of curves illustrated were selected because they are representative of the bleeding characteristics of the more common types of lubricants. In Figure 4, bleeding vs. temperature data is reported on several greases after 5,000 hours of test. Again the oil losses in both the petroleum greases are significantly greater than the diester and silicone lubricants above 100°C.

For maximum efficiency, the release of oil from a grease should occur at a steady optimum rate. If this rate could be established and maintained for a given set of conditions, the ultimate in grease life

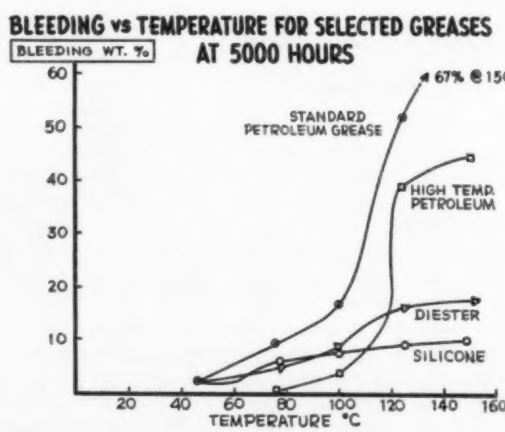


FIGURE 4

could be realized. To some extent, the bearing may automatically increase bleeding as it encounters more severe conditions of load, etc., resulting in a higher temperature.

Farrington and Humphries[1] have studied the loss of oil from greases during pressure filtration and found that the results can be expressed by the following equation

$$B = \frac{t}{a + bt}$$

where B is the oil loss in percent of the original grease weight at time "t" in hours for any given temperature. This general equation also satisfied the open cone-bleeding data for phthalocyanine greases examined by Fitzsimmons et al[2]. Likewise this expression describes the characteristics of all the greases considered in these investigations. Furthermore in reporting and characterizing grease bleeding tendencies, it has been found convenient to list the constants (a) and (b) as well as the reciprocals for each grease at various temperatures. The constants for a selected number of greases are reported in Table I.

By comparing the values of these constants for different greases and temperatures, an idea of the variation in bleeding characteristics may be obtained and, of course, a calculated percent bleeding for any desired time. The best greases, that is greases which have a tendency to bleed slowly at a regular rate will have a large value for (a) representing a low initial bleeding rate and a small (b) denoting high oil utilization and long useful life. The order of magnitude of these values as seen in Table I will vary from grease to grease and with temperature. In general constants (a) and (b) decrease with temperature while the recriprocals, initial bleeding rate and ultimate bleeding, necessarily increase.

At least two other factors have measurable influences on bleeding propensities. At temperatures of 100-150°C phase changes can occur, particularly in the soda base lubricants. The new condition of the fibrous crystallites could thus lead to other bleeding tendencies not necessarily defined by the original expression. In other words new values of the constants (a) and (b) should be obtained. Also, at these higher temperatures, oil evaporation may become sufficiently high such that the determined bleeding results appear nominal and therefore indicate a satisfactory grease. Actually evaporation characteristics which are of indirect concern in this report should be of equal concern when deciding on the suitability of a grease for high temperature application[6]. For example, in Table I the ultimate percent bleeding shows a decreasing tendency at 150°C for the lithium-polyglycol grease. A check of the evaporation data reveals 70-80 percent loss occurs in less than 1,000 hours. Thus in addition to exceptionally high values of ultimate percent bleeding, low values showing a decreasing tendency as the temperature increases signal the possibility that a grease is not suited for a particular temperature level.

At lower test temperatures, it is noted that ultimate per cent bleeding predicted by the bleeding equations for static tests can be much less than the actual amount of oil lost by a grease in a ball bearing. The analysis of the used grease after bearing failure has shown

TABLE I

Bleeding Constants[(a)] for Greases

Grease	*a*			*b*			*Initial Bleeding Rate Per cent/Hr.* 1/*a*			*Ultimate Per cent Bleeding* 1/*b*		
	75°C	100°C	150°C	75°C	100°C	150°C	75°C	100°C	150°C	75°C	100°C	150°C
A–Na-Ca paraffinic	35	12	1	.124	.062	.016	.03	.08	1.0	8.1	16.2	62.5
B–Na-Ca paraffinic	60	50	6.5	.27	.134	.017	.016	.02	.15	3.7	7.5	59.0
C–Sr-paraffinic	20	16	2.0	.048	.037	.024	.05	.06	0.5	21	27.0	42.0
D–Na-paraffinic	49	28	3.0	.144	.124	.018	.02	.04	.33	6.9	8.1	55.5
E–Li-Silicone	51	15	12	.189	.113	.088	.02	.07	.08	5.3	8.8	11.3
F–Na-paraffinic	32	77	2.0	.278	.388	.018	.03	.01	.5	3.6	2.6	55.5
G–Li-polyglycol	1040	45	60	.657	.390	.424	.001	.02	.016	1.5	2.5	2.3
H–Li-diester	30	16	10.0	.235	.112	.067	.03	.06	.1	4.3	9.0	15.0
I–Li-naphthenic	27	12	7	.179	.143	.014	.04	.08	.14	5.6	7.0	71.4
J–Na-Ca paraffinic	610	142	2	17	.525	.019	.002	.01	.5	.06	1.9	52.6
K–Na-naphthenic	...	50	...	...	.175	...	...	.02	...	...	5.6	...
L–Na-naphthenic	...	52	...	...	.09	...	...	.02	...	...	11.1	...

(a) Values determined from general equation $B = \frac{t}{a + bt}$ for each grease at each temperature.

TABLE II

Relation of Grease Bearing Performance to Predicted Life (Bleeding) @ 150°C

Grease	*Original Oil Content % by Wt.*	*Oil Content at Failure % by Wt.*	*% Oil Lost (Total Loss) (a)*	*Geom. Mean Bearing Life Hrs. (b)*	*Ultimate Bleeding Life Hrs. (c)*	*Total Loss Life Hrs. (d)*
A—Na-Ca paraffinic	79	44	62.5	120	62.5	350
B—Na-Ca paraffinic	71	52	40	700	380	600
C—Sr-paraffinic	75	48	52	850	82	3200
D—Na-paraffinic	74	28	64	630	166	2300
E—Li-silicone	72	54	40	2100	135	5000
F—Na-paraffinic	80	56	54.6	100	111.0	240
G—Li-polyglycol	82	40	70	180	138	2650
J—Na-Ca paraffinic	83	44	70	570	105	2300
K—Na-naphthenic	76	46	...	150	....	....
L—Na-naphthenic	70	50	...	160	....	....

(a) Calculated from oil content at failure.
(b) Based on ball bearing grease life tests in No. 306 open bearings, 3600 RPM, 160# radial load.
(c) $\frac{a}{b}$ for each grease (hrs./% x ultimate % bleeding)
(d) Predicted bearing life from bleeding tests based on actual oil loss.

that the amount of oil consumed would be approximately equivalent to an ultimate bleeding of 50 per cent[5].

The difference between the two results serves to remind us that other factors, in addition to those mentioned, also influence the release of oil from a grease in an operating bearing.

Initial bleeding rate not being a linear index of the rate of consumption for lubrication needs, the ratio of ultimate per cent to initial bleeding rate has no apparent significance and therefore can not be used directly to approximate the useful life of a grease in a bearing. It is probably naive to expect that so simple a relationship would exist in a system controlled by so many independent variables. However, in Table II, a comparison at 150°C can be made between the geometric mean life as determined in ball bearing tests and the predicted life based on the simple bleeding tests for several greases. Although the oil content at failure for each grease is roughly of the same order of magnitude, there is no functional dependency evidenced in the tabulations based on either the ratio $\frac{a}{b}$ or the relation of per cent oil lost in the grease of failed bearings to the respective bleeding total loss versus time curves. Thus, if a useful relationship exists, its resolution depends on a more sophisticated approach.

In Figure 5, the bleeding or total oil loss curves are shown with the corresponding curves for the oil losses occuring in the same greases running in 306 open bearings at 3,600 rpm and 100°C[3]. It is interesting to note that the curves for each condition are quite similar; in fact it appears the curves for the bearing tests also are hyperbolic and therefore may be expressed by an equation similar to that describing bleeding losses. This observation appears of sufficient interest to warrant further study. The spread between the curves for each grease shown may be considered a graphical presentation of a possible correlation coefficient relating static bleeding results and the actual oil squeezed from a grease in an operating bearing. It is then likely that similar greases, classified on the basis of soap and oil properties, would qualify under a set of standard coefficients relating static bleeding to the actual losses occuring in a set of reference bearings. With this data, a corrected bleeding curve could be obtained for a new grease and the

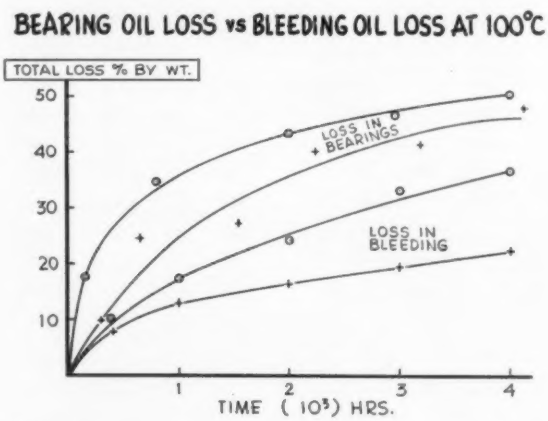


FIGURE 5

TABLE III

Bleeding Rate Constants

Grease	Temp. °C	a Hrs./%	b Per Cent^{-1}	Bleeding Rate at Failure* %/Hr.x10^3	Oil Viscosity Centi-stokes
A–Na-Ca	75	60	0.27		
paraffinic	100	50	0.134	0.122	11.9
	125	29.9	0.018	6.14	6.3
	150	6.5	0.017	19.2	4.1
C–Sr-	75	20	0.048		
paraffinic	100	16	0.037	0.10	32.5
	125	5	0.025	1.3	16.5
	150	2	0.024	4.5	9.7
G–Li-	75	1040	0.657		
polyglycol	100	45	0.390		
	125	157	1.3		
	150	60	0.424	3.2	14.5
I–Li-	75	27	0.179		
naphthenic	100	12	0.143	0.01	9.1
	125	15	0.081	4.1	5.2
	150	7	0.014	7.7	3.2
E–Li-	75	50	0.189		
silicone	100	15	0.113		
	125	15	0.105		
	150	12	0.088	0.3	14.4

*Calculated from "a" and "b" for failure times in 3600 rpm; No. 306 open ball bearing grease life tests.

time noted for a 50-60 per cent loss to occur—the approximate bearing life under the reference conditions. Although not a clean cut technique, it would be of some value in estimating ball bearing life with a specific lubricant.

We have observed the effect of temperature on grease bleeding in the static tests and since temperature also is a factor in bearing operation, we can expect the bleeding trends, although not directly measurable in an operating ball bearing, to be similar.

In addition to accounting for possible soap structure changes, temperature will produce variations in oil viscosity. In Table III several grease bleeding rates corresponding to the failure time in life tests on 306 open bearings running at 3600 rpm are reported with the grease oil viscosities at the stated temperatures. Figure 6 is a plot of the same data. It can be seen that the bleeding rate required is higher as the temperature increases. In addition to viscosity changes per se, this is due to other factors including increased volatility, greater mobility, and increased oxidation rate, all of which promote a faster loss of oil from the bearing races. Also it may be accepted that bearings intrinsically require different amounts of oil[7] since conditions attributed to surface finish, design and construction must be satisfied.

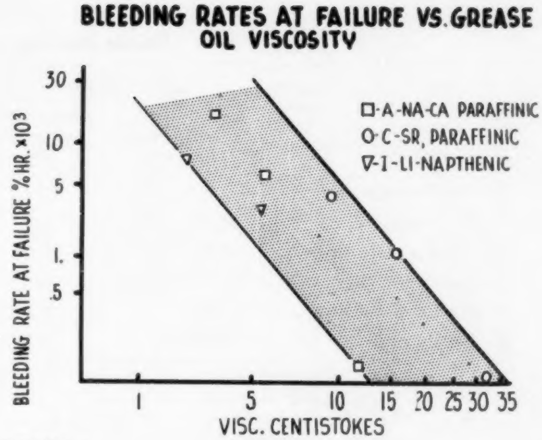


FIGURE 6

With increasing bearing speed, grease is subjected to greater shear, faster squeezing action and higher local temperature. Therefore, we can conclude that the oil loss rate will increase to match these conditions as well as supply any additional oil needed to satisfy the bearing. In Table IV bearing life and the corresponding bleeding rates at failure are listed at various DN values. It can be seen that the bleeding rates increase directly with increasing DN number and this increase is an order of magnitude difference between the two speed factors 1 x 105 and 3.85 x 105. Although it may be fortuitous the greases providing the lowest bearing life at the highest DN number exhibit the lowest and nearly identical bleeding rates at failure.

Figure 7 is a plot of the data for four of the greases listed in Table IV. It is of interest to note that the curve of the lithium-silicone grease has the steepest slope indicating that it is not as adaptable to as wide a range of operating speeds as the other grease types. This is in agreement with practical experience with

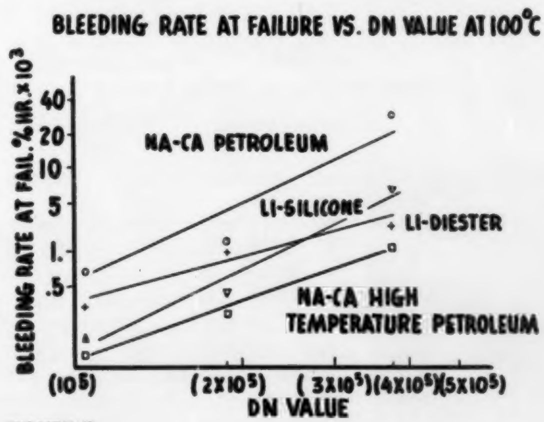


FIGURE 7

TABLE IV

Grease Bleeding vs. Speed Factor at 100°C

Grease	DN = 108,000 (a) Geom. Mean Life, Hrs.	DN = 108,000 (a) Bleeding Rate at Failure %/Hr.x10[3]	DN = 187,000 (b) Geom. Mean Life, Hrs.	DN = 187,000 (b) Bleeding Rate at Failure %/Hr.x10[3]	DN = 385,000 (c) Geom. Mean Life, Hrs.	DN = 385,000 (c) Bleeding Rate at Failure %/Hr.x10[3]
K–Na-naphthenic	2,000 (52)[d]	0.31	....	..	1000 (60)[d]	1.0
H–Li-diester	1,900 (56)	0.30	1,000	.97	800 (65)	1.4
A–Na-Ca paraffinic	2,000 (53)	0.64	1,500	1.1	250 (59)	15.3
L–Na-naphthenic	2,500 (46)	0.67	....	..	560 (53)	4.9
B–Na-Ca paraffinic	4,400	0.12	2,800	.27	1800 (56)	1.0
E–Li-silicone	2,500[e]	0.17	1,700	.35	500	2.9

(a) 30 mm. x 3600 rpm
(b) 17 mm. x 11,000 rpm
(c) 35 mm. x 11,000 rpm
(d) % oil in grease at failure
(e) Estimate based on DN life coef.

silicone greases. In contrast, the lithium-diester lubricant has the flattest curve and therefore more speed adaptability. Several other diester greases examined display the same characteristic.

Another interesting observation with regard to the bleeding-DN number comparisons is that grease exhibiting extremes in bleeding tend to be less suitable for wide operating speed ranges.

As previously noted, the grease oil content at failure is consistent with values generally ranging from 50-60 per cent regardless of the speed range examined.[5]

The general trend as well as the need in lubrication especially for aircraft applications is to greater precision, increased reliability and longer life under more severe conditions of operation. As a result, more of the so-called precision and special bearings are used. Some idea of the effect of precision on grease requirements can be seen in Table V. The favorable influence of "precision" on bearing performance, i.e. lower grease bleeding rates, is observed at both temperatures, and, as you might predict, the effect is more pronounced at the lower temperature. The obvious conclusion then is that less oil is needed to lubricate bearings made to closer tolerances.

TABLE V

Grease Bleeding vs. Bearing Precision

Grease	Standard Bearing (ABEC-1) Geom. Mean Life, Hrs.	Standard Bearing (ABEC-1) Bleeding Rate at Failure %/Hr.x10[3]	Precision Bearing (ABEC-5) Geom. Mean Life, Hrs.	Precision Bearing (ABEC-5) Bleeding Rate at Failure %/Hr.x10[3]
A–Na-Ca paraffinic*	2,000	2.87	4,400	0.9
C–Sr-paraffinic†	800	4.4	900	3.6

*3600 RPM, 100°C
†3600 RPM, 150°C

V. Summary

Grease bleeding is a significant factor in ball-bearing performance. It affects bearing life and in turn is affected by operating conditions. Raising the operating temperature accelerates bleeding to the point where the oil released exceeds the needs of a bearing and shortens the useful life. This effect is more pronounced with petroleum based greases. It appears that bearings operating at high temperatures do not require significantly higher bleeding rates to insure long life. A grease, in lubricating a ball bearing, releases oil to the bearing in a manner which is characteristic of the action observed under static conditions.

Reference to a tabulation of constants derived from the bleeding equation for each grease at various temperatures is helpful in indicating the relative suitability of a grease for use over a wide range of temperature.

BALL bearing grease life tester is shown with Thomas Cooke. Four bearings in the unit are maintained at constant load and temperature until one of them fails. The running time is then related to the bleeding rate of the grease used.

TABLE VI

Grease Compositions and Properties

Grease	*Soap Base*	*Oil Type*	*% Oil*	*Oil Visc. SUS @ 100°F*	*Melting Point °F*	*Worked Penetration @ 77°F*
A	Na-Ca	Paraffinic	79	300	347	280
B	Na-Ca	Paraffinic	71	750	374	195
C	Sr	Paraffinic	75	2200	450+	290
D	Na	Paraffinic	72	490	400+	280
E	Li	Silicone	72	600	400+	260
F	Na	Paraffinic	80	150	300+	280
G	Li	Polyglycol	82	1256	404	229
H	Li	Diester	84	70	350	275
I	Li	Naphthenic	92	500	380	275
J	Na-Ca	Paraffinic	83	390	350	240
K	Na	Naphthenic	76	300	450	285
L	Na	Naphthenic	70	500	500	200

Values, when compared, that show extremes in bleeding tendencies indicate shorter bearing life. A more sophisticated analysis is required, however, in order to resolve a quantitative evaluation of grease bearing life on the basis of bleeding.

Bleeding rates generally increase with temperature but greases exhibiting smaller changes in rate appear to be better lubricants. Such changes in rate can be attributed more to oxidative structure, viscosity and volatility changes than perhaps some operating variables.

Greases which in general have lower bleeding tendencies are more adaptable to wider speed ranges. Specifically, silicones show to poor advantage in comparison with diester greases, and the conventional petroleum base lubricants are intermediate in this respect with the so-called high temperature lubricants being slightly better.

When precision bearings are used, the bleeding requirements are less critical and longer life can be obtained with greases exhibiting lower bleeding rates.

Some bleeding and evaporation limits are noted for certain applications. For electric motors, greases having initial bleeding rates in cone bleeding tests of about 0.2 per cent per hour at 100°C or a maximum of 10 per cent in 500 hours are the best. A lower limit of 2 to 3 per cent also should be indicated to insure that the grease provides sufficient bleeding and feeding to keep the bearing adequately oiled.[1] Very low bleeding results in erratic life with early failures. Although not directly involved in this discussion on bleeding, volatility of the released oil should be reviewed in the over-all considerations. It is axiomatic that losses due to evaporation should be a minimum and experience has shown that the greases exhibiting losses less than 2 per cent by weight in 500 hrs. at 100°C are desirable.[1] ■

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About the Author

A. E. Baker *graduated from Northeastern university with a B. S. in chemical engineering. His graduate work was done at Tufts college and M. I. T. after which he served with the USAF during World War II. He joined General Electric's Thompson laboratory in 1945 as leader of the group concerned with application, development and physical properties of lubricants and fuels. Since 1956 he has been manager of chemical engineering in the materials processes lab of General Electric's aircraft accessory turbine department. His present studies are concerned with solutions to the fuel, lubrication and high speed bearing problems facing present and future aircrafts and missiles. Mr. Baker is a member of ASLE, ASTM and AOA.*

TENSIVE STRESSES ON LUBRICATING GREASE REDUCE BLEEDING

By Dean W. Criddle and Jay Cortes, Jr.
California Research Corporation

Presented at the NLGI 25th annual meeting in Chicago, October, 1957

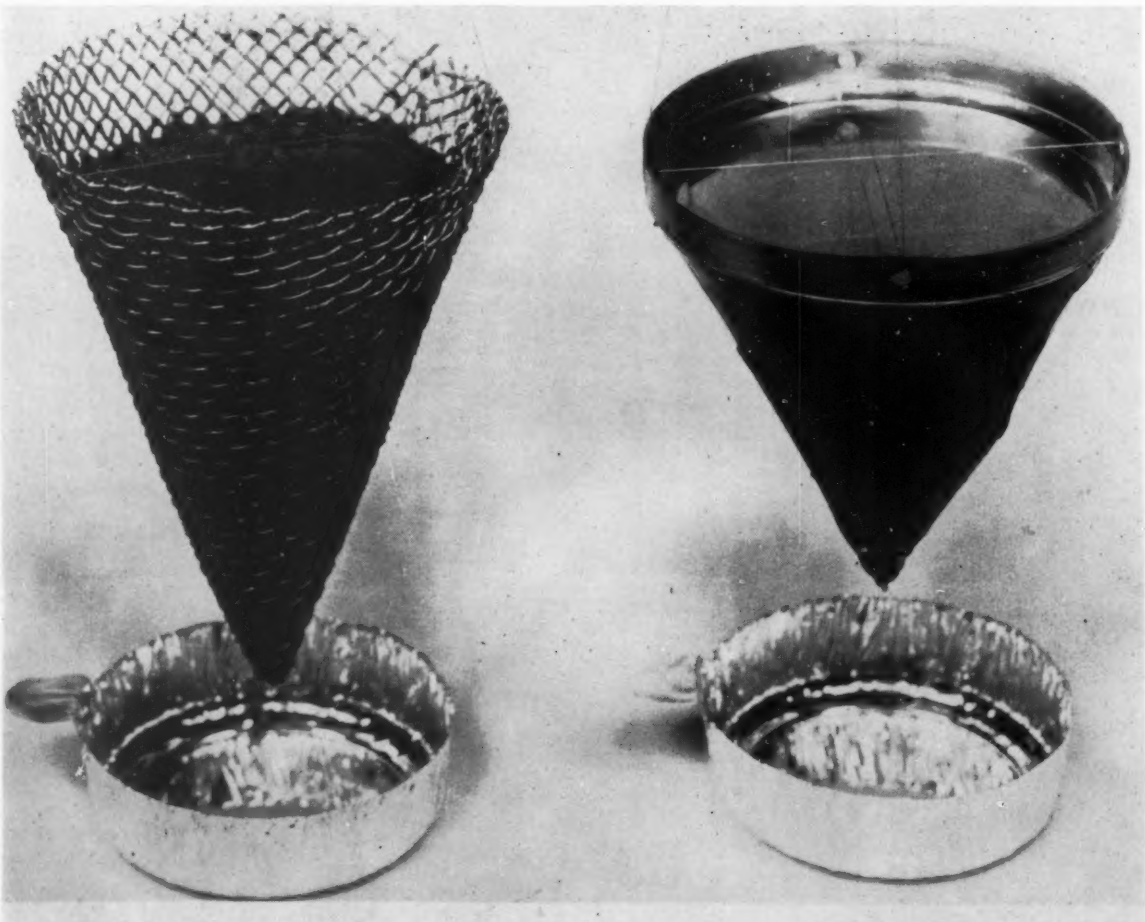
COMPRESSIVE TENSIVE

FIGURE 1, Test equipment to study the effect of stress on grease bleeding.

TESTS by Ralph Clark show that tension reduces bleeding. The samples in screened cones with apex up (tension) bleed less than those with apex down (compression).

MANY DIFFERENT TESTS are used to evaluate the bleeding of greases. The results of these tests usually correlate poorly with each other and with field storage experience.[1] Cooperative groups[2,3] currently are seeking accelerated bleeding tests that correlate with field experience. Our analysis of the effects of the stresses acting in grease helps explain the poor correlation between many bleeding test results. Both tensive and compressive stresses are considered in this paper, and shear stresses are assumed to be unimportant.

Effect of Tension on Bleeding

The effect of tension on bleeding can be demonstrated in the following three ways: (1) if grease hangs from a surface, its own weight acts as a tensive force and bleeding is reduced, (2) open containers of grease stored with bottoms up show no signs of bleeding even after seven months, and (3) grease does not bleed when it is stored in vertical cylinders with screen tops and no bottoms.

Cone-shaped samples hanging from horizontal surfaces were used to study tensive effects on bleeding, and samples contained in screen cones were used to study compressive effects. Test samples and apparatus are shown in Figure 1. Twenty-five greases were studied covering a wide range of compositions and consistencies. Tests were run in duplicate or triplicate, using 100-gram samples in each case. Bleeding tests under tension used cones of grease 8.7 cm in diameter at the top. Bleeding under compression was studied with 8-mesh screen cones, 10.3-cm high by 7.7-cm basal diameter.

Throughout this paper, the amount of oil bled from grease under the compression of its own weight is designated by "B_c." The amount of oil bled from samples of grease adhering to a horizontal surface (in tension) is designated as "B_t."

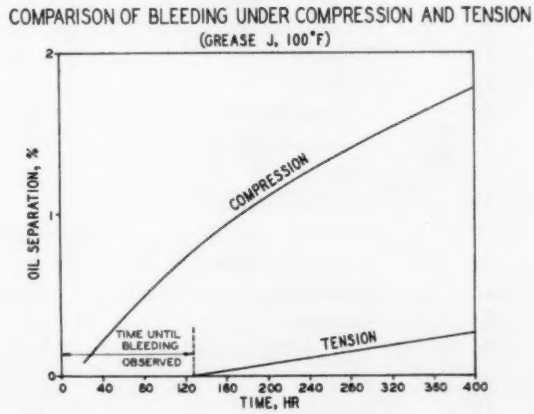

FIGURE 2

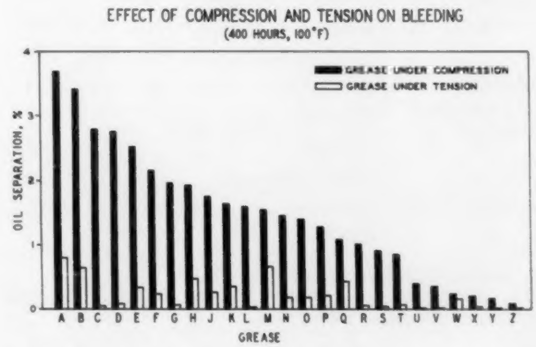

FIGURE 3

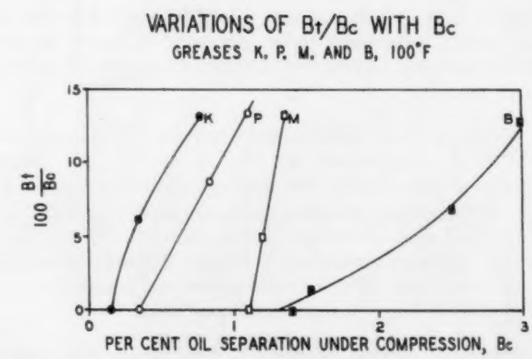

FIGURE 4

TABLE I

Composition and Properties of Test Greases

Greases Arranged in Order of Decreasing B_c After 400 Hours at 100°F

	Thickener		Mineral Oil		
Grease	*Soap Type*	*Per Cent*	*Viscosity SSU at 100°F*	*Viscosity Index*	*ASTM Worked Penetration*
A	Sodium Stearate	20	103	94	311
B	Sodium Oleate	16	103	94	312
C	Sodium[1]	9	330	50	311
D	Sodium[1]	18	413	10	315
E	Lithium-Barium[1]	12	450	88	336
F	Sodium-Calcium[1]	12	280	75	315
G	Sodium[1]	28	500	86	277
H	Lithium Stearate	11	103	94	320
J	Lithium[1]	8	696	19	287
K	Lithium Stearate	14	103	94	303
L	Lithium-Calcium[1]	10	1090	60	295
M	Bentone	6	439	82	344
N	Lithium-Barium[1]	14	450	88	293
O	Lithium[1]	8	479	56	284
P	Sodium Oleate	18	103	94	278
Q	GA-10[2]	8	500	86	345
R	Lithium-Calcium[1]	20	58[3]	100	285
S	Lithium-Calcium[1]	15	150	60	275
T	Lithium Stearate	17	103	94	270
U	Sodium[1]	14	1320	40	280
V	GA-10[2]	12	625	86	250
W	GA-10[2]	9	500	85	290
X	Lithium Stearate	20	103	94	246
Y	Calcium[1]	12	1955	60	330
Z	Calcium[1]	13	1050	80	284

1. Soap of commercial mixed fatty acids.
2. Sodium salt of Oronite GA-10 (Methyl N-octadecylterephthalamate).
3. Diester-mineral oil blend.

Typical bleeding curves are shown in Figure 2 for grease "J." Both "B_c" and "B_t" at 100°F are plotted against time for this grease. Bleeding started within a few hours for greases in compression. A much longer delay occurred before the start of bleeding from greases in tension.

Bleeding tests were conducted on 25 greases at 100°F. A comparison of "B_c" and "B_t" for these greases at 100°F after 400 hours is shown in Figure 3. The composition and properties of the test greases are given in Table I. Changes in the ratio of "B_t" to "B_c" as "B_c" changes are shown in Figure 4. Since the intercepts and slopes vary with the grease, we conclude that "B_t" and "B_c" are independent quantities.

The delay period before bleeding begins for cone-shaped grease samples under tension depends upon the grease (Figure 5). For greases with different concentrations of the same thickener, the delay increases as the proportion of thickener increases. Greases which bleed most have the shortest delay. For greases with different thickeners, the delay does not correlate with thickener concentration or oil viscosity.

Bleeding was studied on seven greases under both tensive and compressive conditions at 77°F and 100°F. In every case, "B_c" was greater than "B_t." In general, for tests lasting 400 hours, an increase in temperature from 77°F to 100°F doubled "B_c" and "B_t" and halved the delay before bleeding began from greases in tension.

Effects of Size and Shape of Grease Sample on Bleeding

The per cent oil separated from a given grease in any bleeding test depends upon the temperature, the pres-

sure, and the size and shape of the grease and test apparatus. Using a constant size and shape for the test apparatus and the grease sample, investigators have shown the dependency of bleeding on pressure[4], centrifugal force [1], and temperature. [5, 6, 7] The variation of bleeding with change of size and shape of the grease sample and test apparatus is clarified by considering the stresses involved.

We find that for a given temperature, grease bleeding data obtained from a wide variety of tests and sample sizes can be explained as follows: (1) grease under compression bleeds at a rate dependent upon the grease, the area of the bleeding interface, and the pressure available at the interface; and (2) grease under tension bleeds at a lower rate than anticipated from (1). Tension acts as if it tends to expand the gel structure

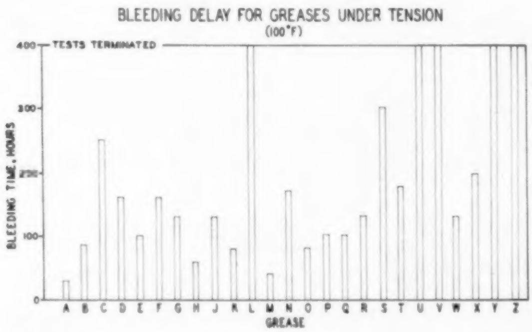

FIGURE 5

and thus prevent bleeding. Based on (1), an equation is derived in the appendix which theoretically relates the initial bleeding rate of greases in screen cones to the apex angle and the amount of grease. Thus, from Equation 7 of the appendix, the initial bleeding rate per weight of grease, $\frac{\frac{dB}{dt}}{W}$ is given by

$$\frac{\frac{dB}{dt}}{W} = \frac{k}{\sin\theta}$$

where "k" is a bleeding rate constant characteristic of the grease, "W" is the weight of grease and 2θ is the apex angle. Initial bleeding rates per volume of grease should be independent of the amount of grease in cones with the same apex angle. This was observed in the experiments. If tension effects are constant or negligible, the same proportion of oil should bleed at a later time from different amounts of grease in cones with the same apex angles. A constant per cent bleeding was found for different volumes of grease "D" after 200 hours as shown by the data in Figure 6.

The effect of apex angle on bleeding rates from screen cones is also predicted by Equation 7 of the

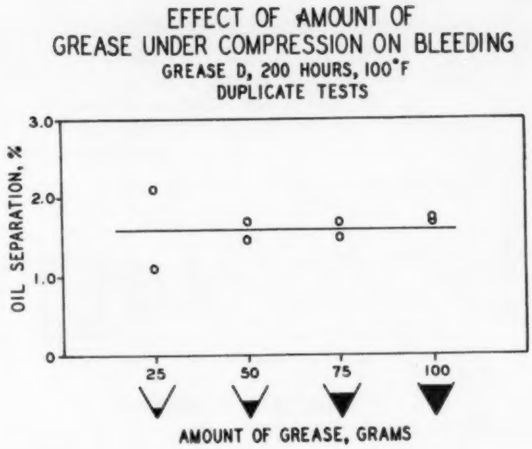

FIGURE 6

appendix. If tension is constant or negligible, then with a constant amount of grease more bleeding would occur from cones with small than with large apex angles. On the contrary, it was found that there was more bleeding from short cones with large apex angles than from tall cones with small apex angles (Figure 7). These results are now readily explained. More of the grease is under tension in small than in large-angle cones during the test; hence, grease in small-angle cones bleeds less.

The origin of tensive forces is explained as follows. Tensive stresses arise when the grease bleeds and the volume of the grease decreases. This causes the grease in the central region of the cone to sag. Such sagging puts more of the grease under tension, particularly in small-apex angle cones. The increasing effect of tension,

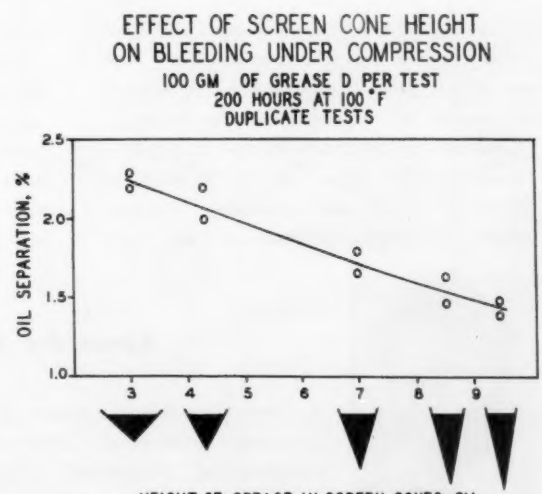

FIGURE 7

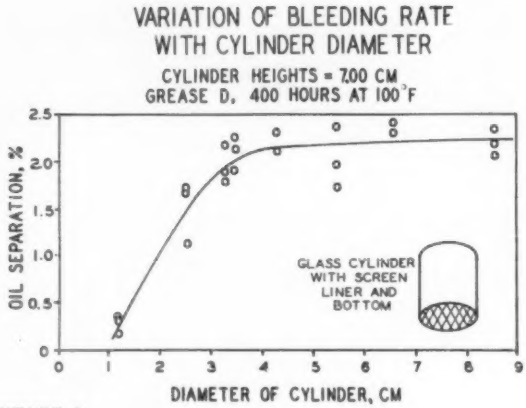

FIGURE 8

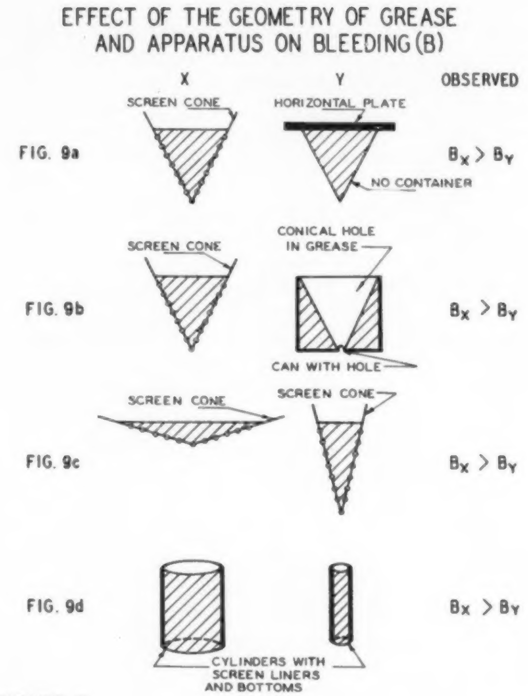

FIGURE 9

as the bleeding test progresses, is one of the factors acting to reduce the bleeding rate of the grease.

Tensive stresses are also important in cylindrical containers. A smaller percentage of oil bleeds from small than from large-diameter cylinders due to tension effects. The quantitative effect for Grease "D" is shown in Figure 8. The effect is expected to apply to all greases.

The dependency of bleeding on the size and shape of the grease sample and test apparatus is summarized for four cases in Figure 9. Each case compares two tests and uses grease at the same temperature. Bleeding from a screen cone is compared in Figure 9a to the bleeding from a cone-shaped mass of grease under the tension of its own weight as it hangs from a horizontal surface. Bleeding from a screen cone is compared to bleeding in the Union three-ounce crater bleeding test[5] in Figure 9b. Bleeding from cones with large and small apex angles is compared in Figure 9c. In Figure 9d bleeding from screen-lined cylinders of the same height but of different diameters is compared. The liners provide a rough surface to which the grease adheres. In

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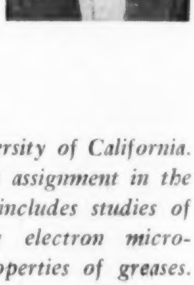

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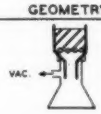
each of the four cases illustrated in Figure 9, the test to the right has more significant tension effects and a lower bleeding rate.

Analysis of Some Current Bleeding Tests

Several bleeding tests are described in current literature and military specifications.[7, 8, 9, 10] A summary of eleven of the principal tests and an analysis of the relative amount of grease under tension are presented in Figure 10. These tests are arranged in an order determined by the stress in the grease, with highest compressive stress first and highest tensive stress last.

The first four tests of Figure 10 use compression to hasten bleeding. The compressive stresses in these four tests are obtained by applying vacuum, centrifugal force, weights, and air pressure. The compressive stresses ranging from 13 psi in Test No. 1 to 0.35 psi in Test No. 4 are so large that tensive stresses are of minor importance.

In view of the effects of size and shape of the grease and apparatus summarized in Figure 9, one expects part of the grease in Tests No. 5 through 9 of Figure 10 to be under tension. Part of the poor correlation between these bleeding tests is attributed to differing proportions of the grease being under tension, and these proportions vary with greases of different yield point.

NUMBER	TEST		REFERENCE	TEST CONDITIONS					RELATIVE AMOUNT OF GREASE UNDER TENSION
							BLEEDING INTERFACE		
	NAME	GEOMETRY		TIME (HOURS)	TEMP. (°F)	AMOUNT OF GREASE (GM)	CONSISTS OF GREASE, AIR AND	COMPRESSIVE STRESS (LB/IN^2)	
1.	VACUUM FILTRATION		6	1-5	AS SELECTED	60	FILTER PAPER	13	NONE
2.	CENTRIFUGAL FILTRATION		1	0.5	77	1	FILTER PAPER	5	NONE
3.	HERSCHEL PRESS		4	0.5-2	77	2	FILTER PAPER	2	NONE
4.	MIL-G-10924 A		9	24	77	100	WIRE SCREEN	0.35	NONE
5	CRATERED PAIL		1	672 (4 WEEKS)	77	15, 850 (35 LB. PAIL)	WIRE SCREEN	<H*	NONE TO SMALL
6	MIL-G-3278A		10	30	210	10	WIRE SCREEN	<H*	SMALL
7.	MIL-G-10924 (AMEND 2)		8	50	160	10	PERFORATED CONE	<H*	SMALL
8.	CONES OF GREASE UNDER COMPRESSION		TEXT	400	100	100	WIRE SCREEN	<H*	SMALL TO MEDIUM
9.	UNION THREE-OUNCE CRATER		5	200	130	48	NOTHING	<H*	LARGE
10.	CONES OF GREASE UNDER TENSION		TEXT	400	100	100	NOTHING	0	ALL
11.	CLOSED CYLINDER		TEXT	400	100	100	NOTHING	0	ALL

H*, APPARENT HYDROSTATIC HEAD

FIGURE 10, Summary of bleeding tests.

Bleeding tests in which tensive stresses predominate are illustrated in Tests No. 10 and 11 (Figure 10). In these two cases, the grease is under the tension of its own weight. The bleeding rate in Test No. 10 is low, and no bleeding was observed in Test No. 11.

Summary

This work shows that the bleeding rate of a grease depends upon the tensive as well as the compressive forces on the sample. A variety of greases differed widely in their response to tensive and compressive forces. The size and shape of the grease sample and apparatus affect bleeding rates as expected from an analysis of the tensive and compressive forces on the grease. Usually, the proportion of a sample under tension and under compression varies with the grease and test; hence, the results of many bleeding tests do not and should not correlate. Some current bleeding tests are summarized and classified in terms of the relative tensive or compressive stresses involved.

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4. Farrington, B. B., and Humphreys, R. L., "The Effect of Pressure on Lubricating Greases," *Ind. Eng. Chem.*, 31, 230 (1939).
5. Smith, T. D., Amott, E., and McLennan, L. W., "The Syneresis of Lubricating Oil Greases," *Institute Spokesman*, 14, 10 (1950).
6. Hotten, B. W., "Fundamental Knowledge of Lubricating Grease Structure," *Lubrication Engineering*, 8, 244 (1952).
7. Calhoun, S. F., Development of a Method for Determining the Oil Separation Tendencies of Multipurpose Greases," *ASTM Bulletin*, No. 210, 45 (1955).
8. Specification MIL-G-10924, Amendment 2.
9. Specification MIL-G-10924A.
10. Specification MIL-G-3278.

DIAGRAM OF CONE SHAPED GREASE

(SYMBOLS DEFINED IN APPENDIX)

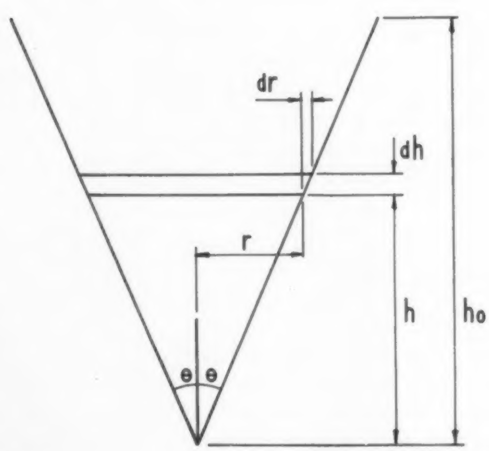

FIGURE A

APPENDIX

Dependence of Initial Bleeding Rate on Cone Size and Shape (Neglecting Tension Effects)

Consider a mesh cone (Figure A) with apex angle 2θ filled with grease to a height, h_o. The cone can be divided into horizontal layers of thickness, dh, with lateral surface area, ds. The surface area, ds, is the bleeding interface of the grease layer. If the initial bleeding rate, db/dt, from a stratum at height, h, depends only on the grease, the hydrostatic pressure[5] (proportional to h_o-h) and on the area, ds, of the bleeding interface, the initial bleeding rate from the stratum (neglecting the effects of tension) is expressed by

$$\frac{db}{dt} = k_1 \,(\text{pressure}) \times (\text{surface area}) \qquad (1)$$

$$= k_1 \,(h_o\text{-}h)\,(2\pi r\sqrt{dr^2 + dh^2}) \qquad (2)$$

$$= k_2 \,(h_o\text{-}h)\,(\tan\theta \sec\theta)\, hdh \qquad (3)$$

where k_1 is a bleeding rate constant for the grease. The initial bleeding rate from the entire cone, dB/dt, is obtained by integration.

$$\frac{dB}{dt} = \int_{h=o}^{h=h_o} \frac{db}{dt} = \int_{h=o}^{h=h_o} k_2 \,(\tan\theta \sec\theta)\,(h_o\text{-}h)hdh \qquad (4)$$

Integrating Equation (4)

$$\frac{dB}{dt} = k_3 \tan\theta \sec\theta\, h_o^3 \qquad (5)$$

The amount of grease in the cone is

$$W = \frac{d\pi r^2 h_o}{3} \text{ where d is the density.}$$

Since $r = h_o \tan\theta$, then

$$W = \frac{d\pi \tan^2\theta h_o^3}{3} \qquad (6)$$

Dividing Equation 5 by Equation 6:

$$\frac{\frac{dB}{dt}}{W} = k\,\frac{\sec\theta}{\tan\theta} = k\,\frac{1}{\sin\theta} = k \csc\theta \qquad (7)$$

Based on the above assumptions, the initial bleeding rate per weight of grease is expected to be: (1) independent of the amount of grease in cones of constant angle, and (2) dependent on the apex angle of the cone.

Patents and Developments

Grease Manufacture With Recycle Cooling

Patent 2,830,022 issued to R. F. Nelson, R. C. Givens, and H. J. Pitman, and assigned to The Texas company. Greases (particularly those containing lithium soaps of hydroxy fatty acids) are prepared by cooling the hot grease down from a temperature above its gelation temperature until a grease consistency is obtained by continuously cooling a recycle stream of the hot mixture and then mixing the cooled recycle stream thoroughly with the main agitated body of its grease. Superior texture and other properties and in much higher yields are obtained than by shock cooling the whole mass of grease either statically or with agitation. By reference to Figure 1, the process may be followed wherein the grease mixture, comprising a slurry of a soap and an oleaginous liquid, is heated in the kettle at above the melting point of the soap for sufficient time to obtain a completely homogeneous mixture. The soap-forming fatty material may be charged into kettle 1 from tank 3, using stirrer 2 for mixing. A stream of the hot grease mixture is continuously circulated through heat exchanger 5 (via pump 10). Circulation through the heat exchanger is begun while the grease is at a temperature above its gelation temperature, and is continued until a grease consistency is obtained. When the grease is to be finished by milling, it is cooled in kettle 1 to about 200°F. or lower, and then passed, via pump 16, to mill 13 and thence to kettle 18 for further cooling and for mixing with additional oil or other additives, from which point it is pumped by pump 22 to the packaging system. Figure 2 presents a chart showing the effect of the cooling rate upon the yield for a lithium 12-hydroxystearate grease. Cooling rates above 4-5°F. per minute have little effect on the soap contents of the greases, resulting in products having 5.5-6.5 per

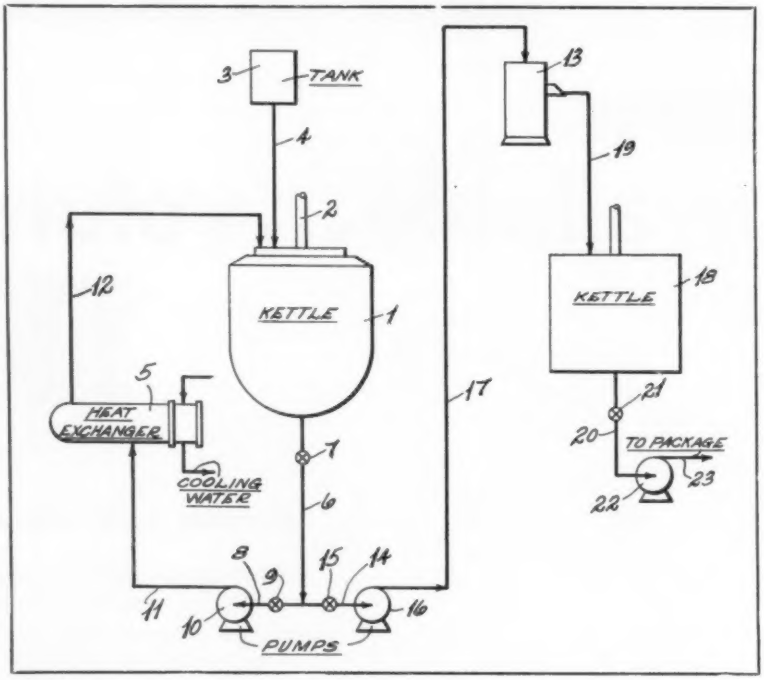

FIGURE 1

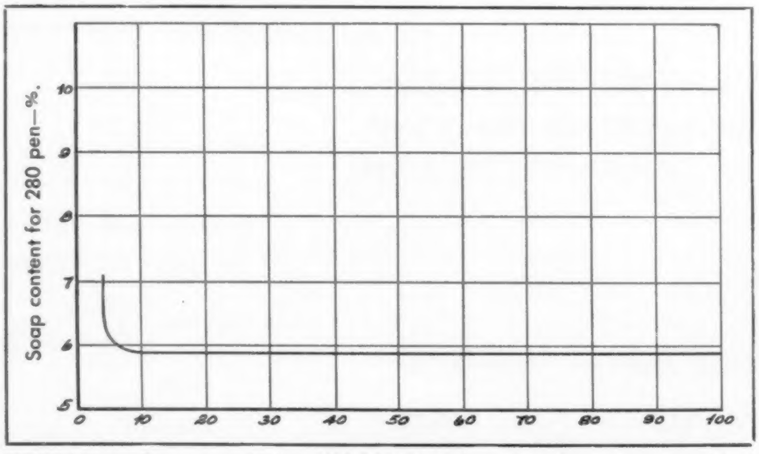

FIGURE 2, cooling rate, of/Min. (400-300 F.) Effect of cooling rate on yield of lithium 12-hydroxystearate grease in temperate range of 400-300 F.

cent soap for a 280 penetration. However, the cooling rate becomes critical at a value of about 4°F., as shown by the fact that the median curve shows a sharp rise of soap contents of this value.

Oils Thickened With Cyanuric Acid Salts

Patent 2,830,020 issued to L. J. Christmann and W. G. Deichert, and assigned to American Cyanamid company. Salts of cyanuric acid were found to be excellent thickening agents for lubricating oils in the production of greases and similar compositions, particularly alkali metal, alkaline earth metal and heavy metal salts as well as amine salts, preferably in an amount of 7-12 per cent by weight. The oil may be mineral oil, polyglycol lubricant, silicone oil, or ester synthetic lubricant.

Polyamide-Thickened Grease

Patent No. 2,830,955 issued to J. A. Dixon, and assigned to California Research corporation. Greases which are capable of maintaining their unctuous consistencies up to 350°F. to 500°F. are claimed to be produced by incorporation into the composition certain polyamide thickeners prepared by reacting a dicarboxylic acid with a diamine wherein the molar ratio thereof is 1.6 to about 4.

The reactions involved in the preparation of these thickeners are as follows:

Equation 1.

$$X(H_2N-R-NH_2) + Y(HO-\overset{O}{\overset{\|}{C}}-R_1-\overset{O}{\overset{\|}{C}}-OH) \xrightarrow{Y/X>1} HO\overset{O}{\overset{\|}{C}}-R_1-\overset{O}{\overset{\|}{C}}-(NH-R-NH-\overset{O}{\overset{\|}{C}}-R_1-\overset{O}{\overset{\|}{C}}-NH-R-NH-\overset{O}{\overset{\|}{C}}-R_1-\overset{O}{\overset{\|}{C}})_z-OH$$

Equation 2.

$$HO\overset{O}{\overset{\|}{C}}-R_1-\overset{O}{\overset{\|}{C}}(NH-R-NH-\overset{O}{\overset{\|}{C}}-R_1-\overset{O}{\overset{\|}{C}}-NH-R-NH-\overset{O}{\overset{\|}{C}}-R_1-\overset{O}{\overset{\|}{C}})-OH + (R_3)(R_4)NH \longrightarrow (R_3)(R_4)N\overset{O}{\overset{\|}{C}}-R_1-\overset{O}{\overset{\|}{C}}-(NH-R-NH-\overset{O}{\overset{\|}{C}}-R_1-\overset{O}{\overset{\|}{C}}-NH-R-NH\overset{O}{\overset{\|}{C}}-R_1-\overset{O}{\overset{\|}{C}})_z-N(R_3)(R_4)$$

in which R, R_1, and R_2 are aliphatic radicals, R_3 is hydrogen or an aliphatic radical, and Y/X is the molar ratio of dibasic acid to diamine (2-3 being preferred). The values of "z" in the equations are not fixed values for any one reaction. In the formation of thickening agents, the "average" value for "z" may vary only from about 1.5 to 4. The R and R_1 groups are polymethylene groups (i.e., $(CH_2)_x$, wherein x is a number from the R groups from 2 to 10. R_2 and R_3 (where R_3 is not hydrogen) are aliphatic radicals containing 2-22 carbon atoms. It is preferred that R is a hexamethylene radical, R_1 a tetramethylene radical, R_2 an aliphatic radical containing

Continued on page 290

Membership Advantages of NLGI

DID YOU KNOW . . .

That the National Lubricating Grease Institute represents over 95 per cent of the lubricating grease industry with members in this country and overseas?

Some of the advantages of membership are listed below:

NLGI has a Technical Committee of 154 members which is divided into nine sub-committees working constantly on industry problems.

Beginning with the production of lubricating grease for the year of 1957, NLGI is instituting a survey which can be of practical value in establishing sales and manufacturing data.

The NLGI Spokesman, a monthly technical journal, is mailed free of charge to key personnel within a member firm. If extra copies of the magazine are needed, they may be purchased at half the regular subscription price.

The Institute works in close cooperation with affiliated groups, including SAE, ASTM, ASA, ASLE, ASME, SAE-CIMTC, and IOCA, on problems and accomplishments in the lubricating field.

The Annual Meeting is the highlight of the year and is usually held during the last week in October. It is a three-day session where papers are presented of unusual interest on technical advances, marketing problems, new developments by suppliers and packagers, and the needs of the consumers. Members of NLGI are allowed a substantial discount on registration fees at this meeting.

Recently NLGI completed production on a new movie entitled "Grease, the Magic Film" which is available at $700 for the first print, $500 for the second print, and $300 for the third and subsequent prints.

Members of NLGI are allowed a $100 discount in each of the above three categories.

The main objectives of the National Lubricating Grease Institute are for the development of better lubricating greases for the consumer and better grease lubrication engineering service to industry.

If your firm is interested in becoming affiliated with NLGI, the national office will be happy to furnish further information concerning the organization. Just as 1957 was a banner year for NLGI accomplishments, 1958 promises to be even better with more scope and more member advantages.

Continued from page 287

4-16 carbon atoms, and that R_3 is hydrogen. When the ratio Y/X in Equation 1 is 1, the resulting polyamide is of the nylon type. The resulting thickening polyamide must have a molecular weight of less than 1000. A suitable polymer is obtained by reacting adipic acid with hexamethylene diamine, followed by reacting the resulting polyamide with n-primary octadecylamine.

Patent 2,830,954 issued to the same patentee, is similar in nature.

Greases Gelled With Polymer-Coated Clays

Patent 2,829,100 issued to J. W. Armstrong, D. M. Preiss and J. A. Edgar, assigned to Shell Development company. Both amino-plasts (e.g., urea-formaldehyde resins) and phenoplasts (e.g., phenol-formaldehyde) are employed to coat the surface of clay hydrogels for thickening oils (preferably silicone fluids) and thus obtain a grease structure. Clay is dispersed in water to form a fluid clay hydrogel to which is added 5-200 per cent (based on the weight of the clay) of an amino compound capable of taking part in a polymerization upon addition of a second copolymerizing ingredient, whereby an unexpected improvement in the filterability of the clay hydrogel occurs. The hydrogel then is filtered or centrifuged from the water and combined with a water miscible organic solvent for the purpose of displacing water to form an organosol of the clay. The latter then is combined with a lubricating oil and the solvent is evaporated. It is preferred to further add the resin-forming ingredients, followed by a heating (curing) step in which the aminoplast is formed on the surface of the clay particles. The resulting grease composition is claimed to be highly resistant to thermal decomposition, oxidation and disintegration in presence of water. It is also preferred to add 1-15 per cent (of the weight of the clay) of strong mineral acid to the clay hydrogel prior to incorporation of the resin-forming ingredients to "activate" the clay, giving it greater gel-forming capacity.

Industry News

New Product Developed by Gulf

A new industrial grease developed especially to be used in bearing applications where high pressures and shock loads exist, or where there is a tendency for fretting corrosion to occur, is announced by the Gulf Oil corporation, Pittsburgh, Pennsylvania.

Identified as Gulfcrown Grease E.P., the new lubricant was formulated to meet severe conditions such as those occurring where loads have been increased above normal, on steel mill rolls, oscillating shafts, rotary kiln bearings, Banbury mixers, crushers, gears, cams, paper machine dryer frame supports, vertical swing shaft gear reductions, etc. In addition to these special applications it can be used in place of other conventional greases and, therefore, can be classed as a multipurpose grease.

The new grease has residual antiweld properties and adhesive characteristics that also make it ideal for applications where infrequent greasing is practiced. Gulfcrown Grease E.P. has excellent water resistance and good pumpability to below freezing. It will also serve the needs of industry at elevated temperatures. This outstanding grease will be found suitable for many applications which, heretofore, have been satisfied by so-called specialty greases.

A highly important feature of Gulfcrown Grease E.P. is that there is no separation of the oil soap base structure when it is subjected to high pressures in central lubricating systems.

Gulfcrown Grease E.P. is available in three N.L.G.I. consistencies, No. 0, 1, and 2. All three types have good oxidation and mechanical stability and rust protection characteristics. Type No. 0 and 1 are especially recommended for central grease systems.

New Cowles Dissolver

Development of a versatile new Cowles Dissolver for high speed mixing of batches of from 50 to 200 gallons has been announced by Cowles Dissolver Company, Cayuga, New York. The new unit, model 510-VH, requires only seven square feet of floor space, yet enables the application of 7½, 10 or 15 H.P. The equipment has wide application in ultimate dispersion, dissolving, emulsifying and deagglomerating in processing solid-liquid, liquid-liquid, or gas-liquid materials of up to 50,000 centipoises.

While in operation, the assembly can be raised by hydraulic lift. Minimum height is 69½", maximum 111½", a rise of 42". The impeller will center in a tank up to 48" in diameter.

Shaft speeds of 890, 1135, 1509, 1750 and 2040 rpm can be quickly attained by use of interchangeable sheaves on the v-belt drive. A selection of impellers is available for maximum performance on various materials.

To multiply the variety of applications of the equipment, the bridge is constructed to swing in a 180° arc and may be locked in any lateral position or height. Entire unit, without motor, weighs approximately 700 lbs.

Full information is available from Morehouse-Cowles, Inc., 1150 San Fernando Road, Los Angeles 65, California.

New Brochure Describes Pallet Racks

A complete line of steel pallet racks for bulky, irregular, fragile and odd-lot materials is described in literature now available from Republic Steel corporation. A new six-page illustrated brochure highlights the design, construction and load-carrying features of the company's heavy-duty adjustable, light-duty adjustable, and fixed rail pallet racks.

Heavy-duty racks safely support loads up to 15,000 pounds per single faced unit, with each rack opening capable of handling a pallet load of 3,000 pounds. Light-duty racks are built to hold two pallet loads per opening, or a total of 7,000 pounds for a single-faced four post unit. The brochure tell show tubular supports adjust on six-inch centers to allow for maximum rack opening adjustment to accommodate palletized material of any height. Fixed rail pallet racks are described as "custom tailored" to solve specific requirements for the continuous storing of bulky, hard-to-handle items.

Brochure EC-2018 is available from Republic Steel corporation, Berger division, 1038 Belden avenue, N.E., Canton 5, Ohio.

Chek-Chart Announces The Publication of Two Manuals

The Chek-Chart corporation announces the release of two of its latest publications as part of the How and Why series, namely: The How and Why of Automotive Lubrication Service and the How and Why of Automatic Transmission Service.

These manuals have been compiled to answer the urgent need for publications that will quickly and completely train service station personnel to be qualified lubrication specialists.

The How and Why of Automotive Lubrication Service covers every phase of modern automotive lubrication. The manual is written in nontechnical language and is thoroughly illustrated to serve both as an excellent source of vital information for the lubrication specialist and as a complete reference text for the service station trainee. Each of the six sections that comprise the manual is individually indexed and collectively cover every phase of automotive lubrication from the proper handling of the lubrication gun to the correct servicing of the very latest type automatic transmission.

Lincoln Engineering Announces New Product— The "Ram-Pump"

Lincoln Engineering company has added a new product to its line of centralized power lubrication systems, company officials have announced. It is the automated "Ram-Pump" which is specifically designed to provide automatic or semi-automatic lubrication of bearings on single machine units while they operate.

Air-operated and controlled either electrically, mechanically or manually, the new "Ram-Pump" system is engineered for O.E.M. applications or existing production facilities. It provides "the lowest cost centralized system available to industry, and one of the most effective," Lincoln reports.

Two models of pumping units are available: one model for low pressure applications of oil; another for high pressure applications of grease or oil.

Among the advantages of the "Ram-Pump" system: "Simple to install; eliminates machine down time for lubrication; frees maintenance personnel for more productive work; cuts number and quantity of lubricants consumed." More detailed information may be obtained by writing for Bulletin No. 812, Lincoln Engineering company, 5702-30 Natural Bridge avenue, St. Louis 20, Missouri.

API Committee Issues New Booklet

The American Petroleum Industries committee of the API has issued a booklet of interest to NLGI'ers . . . "Manual Relating to Federal Excise Taxes on Gasoline, Special Motor Fuels, Diesel Fuel and Lubricating Oil." This booklet supersedes a similar interpretation of federal regulations issued in 1952.

The manual incorporates all rulings of general interest relative to federal excise taxes on petroleum products known to members of the APIC's advisory committee on excise taxation. It also includes suggested forms for exemption certificates and other documentation required by the federal law and regulations.

Copies of the new manual may be obtained by directing orders to Coyne and Company, Inc., 114 East 13th St., New York 3. The booklets are available for $2.00 each.

New Bennett Package-Unit Reduces Pail-Handling Time 90 Per Cent

A new and different way to pack steel pails for shipment was demonstrated recently at the Illinois Central freight yards in Chicago. Called

"Handy-Pak," it reduces the time required to unload a freight car of pails from 21½ to 2½ man-hours. "Handy-Pak" was developed by Bennett Industries, Inc., to ship empty pails to manufacturers. A manufacturer buying steel pails packaged in "Handy-Pak" can save 90 per cent of handling time each time he handles a carload of pails, such as from receiving to storage, storage to filling, filling to storage or shipment—each move can represent a cost savings of $80.00.

This is the most convenient method ever developed to ship steel pails. Furthermore, "Handy-Pak" helps preserve factory fresh appearance of steel pails by protecting them against scuffing and damage.

No capital expenditures are needed for special handling equipment. The 27-pail package can be easily carried by two men from car to storage, or directly to any point on the production line. One man can drag a "Handy-Pak" across the floor. Hand or powered trucks may be used or saved for heavier work.

"Handy-Pak" saves considerable space in storage. It permits pails to be stacked fifteen high instead of nine or ten high, which increases the capacity of a storage area up to 40 per cent.

After filling, the manufacturer can then repack the "Handy-Pak" and ship it to his customers, enabling them to save money in their handling of filled pails.

The new pail-package consists of a top cap and a bottom cap of corrugated board between which 27 steel pails are packed in three layers. The entire assembly is held firm and utilized by steel straps. As the pails cannot move, they are protected from damage, and shippers are spared claims.

A new folder giving full information is available on request from Bennett Industries, Inc., Peotone, Illinois.

Print-a-Can Available for Five-Gallon Pails

Quality printing on five-gallon pails is now possible at extremely

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Technical Committee Column

Chairman T. G. ROEHNER, Socony Mobil Oil Company, Inc.

During the 1957 Annual Meeting of the NLGI Technical Committee, a report was given regarding the status of discussions with SAE Subcommittee C on chassis lubricants concerning a joint project involving chassis lubricating greases. It was stated that a first draft had been prepared to Tentative Recommended Practices for Lubricating Ball Joint Type Front Suspensions. That draft was widely circulated and a number of helpful suggestions were received regarding revisions. The membership of the committee working on this assignment is the following:

L. C. Brunstrom, Standard Oil Company (Indiana); M. Ehrlich, American Lubricants, Inc.; J. J. Kolfenbach, Esso Research & Engineering Co.; T. G. Roehner, Socony Mobil Oil Company, Inc.; J. B. Stucker, The Pure Oil Company.

The recommendation was made to the Board that a new committee be set up having both marketing and technical representation to carry on and complete this project. President Cubicciotti has acted on that recommendation and the chairman of the new committee is F. R. Hart, Standard Oil Company (California).

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Representative—J. H. Kane

The Baker Castor Oil Company
120 Broadway, New York 5, New York
Representative—J. W. Hayes

Baroid Chemicals, Inc.
A subsidiary of National Lead Company
1809 South Coast Life Building
Houston 2, Texas
Representative—Mr. C. M. Finlayson

Godfrey L. Cabot, Inc.
77 Franklin Street
Boston 10, Mass.
Representative—H. P. Donohue, Jr.

Climax Molybdenum Company
500 Fifth Ave., New York 36, New York
Representative—Elwin E. Smith

Darling & Company
4201 South Ashland Ave., Chicago 9, Illinois
Representative—G. W. Trainor

E. I. du Pont de Nemours & Co.
Wilmington, Delaware
Representative—R. O. Bender

The Elco Lubricant Corporation
Jennings Road & Denison Avenue
Cleveland 9, Ohio
Representative—R. K. Smith

Emery Industries, Inc.
4300 Carew Tower, Cincinnati 2, Ohio
Representative—G. W. Boyd

Enjay Company, Inc.
15 West 51st St., New York 19, New York
Representative—Brian Casey

Foote Mineral Company
18 W. Chelten Ave., Philadelphia 44, Penn.
Representative—W. F. Luckenbach

A. Gross and Company
295 Madison Avenue, New York 17, N. Y.
Representative—Eugene W. Adams

The C. P. Hall Company of Illinois
5145 West 67th St., Chicago 38, Illinois
Representative—J. E. Stonis

Harchem Division
Wallace & Tiernan, Inc.
25 Main St., Belleville, N. J.
Representative—W. G. McLeod

Humko—Chemical Department
P. O. Box 4607
Memphis 7, Tennessee
Representative—W. J. O'Connell

Lithium Corporation of America, Inc.
Rand Tower, Minneapolis 2, Minnesota
Representative—Malcolm M. Moore

The Lubrizol Corporation
Box 3057—Euclid Station, Cleveland 17, Ohio
Representative—J. L. Palmer

Mallinckrodt Chemical Works
2nd & Mallinckrodt Sts., St. Louis 7, Missouri
Representative—D. B. Batchelor

The McGean Chemical Co.
Midland Building, 101 Prospect Ave., N. W.
Cleveland 15, Ohio
Representative—W. A. Ritchie

Metasap Chemical Company
A Subsidiary of Nopco Chemical Co.
60 Park Place, Newark, New Jersey
Representative—T. J. Campbell

Monsanto Chemical Company
800 North Twelfth Blvd., St. Louis 1, Mo.
Representative—J. W. Newcombe

Newridge Chemical Company
7025 West 66th Place, Chicago 38, Illinois
Representative—T. E. Shine

M. W. Parsons—Plymouth, Inc.
59 Beekman St., New York City 38, New York
Representative—Herbert Bye

Synthetic Products Company
1636 Wayside Rd., Cleveland 12, Ohio
Representative—Garry B. Curtiss

Swift & Company
165th & Indianapolis Blvd., Hammond, Ind.
Representative—F. H. Beneker

Vegetable Oil Products Co., Inc.
Vopcolene Division
5568 East 61st Street, Los Angeles 22, Calif.
Representative—C. F. Williams

Witco Chemical Company
122 East 42nd St., New York 17, New York
Representative—E. F. Wagner

TECHNICAL AND RESEARCH ORGANIZATIONS

Battelle Memorial Institute
505 King Avenue, Columbus 1, Ohio
Representative—S. L. Cosgrove

Compagnie Francaise De Raffinage
11 Rue du Dr. Lancereaux, Paris VIII^e, France
Representative—Albert E. Miller

Inland Testing Laboratories
6401 Oakton St., Morton Grove, Ill.
Representative—Dr. Morton Fainman

Institut Francais du Petrole
CMrR—Courtel, 4 Place Bir Hackeim
Rueil—Malmaison (S. et Oise) France

Laboratoires de Recherches Purfina S.A.
98/100 Chaussee de Vilvorde,
Bruxelles (N.O.H.), Belgium
Representative—R. Gillerot

Petroleum Educational Institute
9020 Melrose Avenue, Los Angeles 46, Calif.
Representative—G. A. Zamboni

Phoenix Chemical Laboratory, Inc.
3953 W. Shakespeare Ave., Chicago 47, Ill.
Representative—Mrs. G. A. Krawetz

Products Development Laboratory
1 Market St., West Warwick, Rhode Island
Representative—Alberic T. DiMasi

Veresit—Fabrica de Productos Quimicos S.R.L.
Monasterio 271, Buenos Aires, Argentina
Representative—Dr. Alexander Erdely

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low cost with a portable printing device developed by the metal products division of Chapman Chemical company, and now distributed nationally by Bennett Industries, Inc., Peotone, Illinois.

Called the Chapco Print-a-Can printer, the machine will handle up to 500 pails per hour with one inexperienced operator.

It will produce lithographic quality printing without the expense of short runs of lithography. Costs less than paper labels, silk screening or stenciling.

The printing is practically indestructible under normal handling and weathering conditions.

The Print-a-Can printer will handle all types of five-gallon pails . . . open or closed head, with or without rolling hoop. Weighing only 160 pounds, and equipped with casters, it is completely portable. The printer can be rolled to the pails conveniently.

Operation is mechanical, requiring no electric or air power. The machine uses rubber printing plates molded from standard typographic forms or hand set by assembling rubber type on an interlocking base. Each plate is good for many thousands of impressions. Printing area is 9"x14". Type as small as ten point may be reproduced satisfactorily, permitting many times the amount of copy possible with stencils.

Inks are available in most colors. The ink dries to touch when applied so that pails just printed may be put into production lines immediately. Two colors may be applied simultaneously. Plates and colors may be changed in just seconds.

Bennett Industries points out that big savings are possible with the Print-a-Can printer when several products are packaged under the same brand name. Standardized pails may be ordered lithographed with trade name on one side. Specific product identification, quality control numbers, instructions for use, etc., can be applied as pails are needed with the Print-a-Can printer.

An accessory, the Chapco Print-a-Drum printer is available for printing 30 and 55-gallon drums. The same plates can be used.

For prices and additional information, contact Bennett Industries, national distributors.

English-German Glossary Now Available

A bi-lingual lubrication glossary is now available in English-German, covering advanced terminology in the fields of molybdenum disulfide lubrication, molydenum chemistry, and lubricant testing machines. The 26-page mimeograph collection has been gathered by William W. Bower of the Connecticut Translation service. For further information, readers should contact Mr. Bower at 83 Lafayette street, Stamford, Conn.

People in the Industry

A-D-M Appoints Buerki

Appointment of Charles R. Buerki, Minneapolis, as technical sales representative for Archer-Daniels-Midland company's chemical products division in the Cleveland, Ohio, area was announced by James H. Kane, division sales manager.

Buerki, formerly a chemist in ADM's development department, will take over his new duties July 15, with headquarters at ADM's Cleveland sales office, 2191 W. 110th Street. He replaces John K. Lilly.

A graduate of the University of Wisconsin with a bachelor's degree in chemistry, Buerki joined ADM in 1950 as a control chemist. He later was transferred to the research department, where he performed exploratory research, then assigned to the development department in 1955.

Buerki is a member of the American Chemical Society, American Oil Chemists' Society and the Industrial Chemists' Forum.

W. E. Luley as Sales Manager

Buflovak equipment division, Blaw-Knox company, Buffalo, N. Y., announces the appointment of Wilbert E. Luley as sales engineer with headquarters in the company's Chicago office.

Mr. Luley joined Blaw-Knox in 1951 as chief project engineer, and in 1954 was promoted to principal autoclave engineer handling the design of autoclaves, kettles and mixing equipment, the position he held until his recent appointment to the sales staff.

Mr. Luley attended Valparaiso university and received his B.S. degree in mechanical engineering from Purdue university in 1943. After a tour in the Navy, he was employed by the Aluminum Company of America as a plant operating engineer for five years before joining Blaw-Knox.

He is a member of the American Society of Mechanical Engineers, and the American Institute of Chemical Engineers.

E. C. Herrick to Climax

Dr. E. C. Herrick has been appointed chemical research supervisor for the Detroit research laboratory of Climax Molybdenum company of Michigan, a subsidiary of American Metal Climax, Inc., it was announced by A. J. Herzig, president of the subsidiary.

Prior to joining Climax, Dr. Herrick served as a research chemist for Houdry Process Corp., Linwood, Pennsylvania. Formerly, he had been engaged in chemical re-

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search for American Viscose Co., E. I. duPont de Nemours & Co. and the Office of Naval Research at Massachusetts Institute of Technology.

Dr. Herrick received a b.s. in chemical engineering from Montana State college in 1941, an m.s. in chemical engineering from Princeton in 1942 and a ph.d. in organic chemistry from Massachusetts Institute of Technology in 1949. He also attended the Wharton school of the University of Pennsylvania.

The author of numerous technical papers, he also holds several patents in the field of chemical research.

Dr. Herrick is a veteran of World War II, and served with the U. S. Air Force in Europe from 1944 to 1945.

Nopco Appoints West Coast General Sales Manager

Robert J. Kingsley has been named, as of July 1, to the newly created position of general sales manager for the Pacific division of the Nopco Chemical company. The announcement was made by Perc S. Brown, Nopco vice president in charge of western operations.

In addition to his new duties Mr. Kingsley will continue in the capacity of sales manager for the fine chemicals division. As general sales manager, he will be in charge of the new expanded sales program and the administration and direction of sales efforts for all of the company's sales divisions in the eleven western states.

The Pacific division, with sales and production headquarters at Richmond, Calif., produces industrial chemicals such as plasticizers, vinyl stabilizers, lubricants, and polyvinyl acetate emulsions for a wide range of industries, as well as vitamin products for the dairy, feed, and pharmaceutical industries.

E. W. Campbell and R. W. Flynn Named to New Posts by Gulf Oil Corp.

Gulf Oil corporation announced the following promotions in its domestic marketing department. E. W. Campbell has been promoted to coordinator, direct sales, succeeding G. L. Benjamin who was recently made manager, refinery sales with offices in New York City.

Since 1956 Mr. Campbell has been manager, industry and special accounts. Previous to that he was assigned to the contractor market as a salesman and later in a supervisory capacity. He has been with Gulf since 1936. Mr. Campbell is a native of Mercer, Pa., and attended Penn State university.

R. W. Flynn, who succeeds Mr. Campbell, was supervisor of direct sales training. Previous to that assignment he was supervisor, product application in Gulf's New York division. Mr. Flynn is a native of Concord, Mass. He received a b.s. degree in mechanical engineering from Northeastern university and also did postgraduate work at Northwestern. He has been with Gulf since 1933.

Both appointments are effective immediately.